(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 964 423 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
15.12.1999 Bulletin 1999/50

(51) Int. Cl.[6]: H01J 31/12

(21) Application number: 98304629.3

(22) Date of filing: 11.06.1998

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(71) Applicant:
INTERNATIONAL BUSINESS MACHINES CORPORATION
Armonk, NY 10504 (US)

(72) Inventors:
- Beeteson, John Stuart
Skelmorlie, Ayrshire PA17 5DX (GB)
- Knox, Andrew Ramsay
Kilbirnie, Ayrshire KA25 7JZ (GB)
- Pietrzak, Christopher Carlo
Winchester, Hampshire SO22 4BJ (GB)

(74) Representative:
Ling, Christopher John
IBM United Kingdom Limited,
Intellectual Property Department,
Hursley Park
Winchester, Hampshire SO21 2JN (GB)

(54) Grid electrodes for a display device

(57) A magnetic matrix display device has a grid electrode in which differing first grid (G1) and second grid (G2) apertures are used. A sensor element and a second grid electrode are combined as a single structure. Other aspects of the invention relate to the use of a polyimide coating for the grid electrodes, the use of a compliant mounting and adjustment for a grid assembly and the provision of an illuminated border on a magnetic matrix display.

Printed by Xerox (UK) Business Services
2.16.7/3.6

Description

[0001] The present invention relates to a magnetic matrix display device and more particularly to grid electrodes for use in such a display. Yet more particularly, the present invention relates to the use of differing first grid (G1) and second grid (G2) apertures in such a display and to a combined sensor element and second grid electrode. Other aspects of the invention relate to a deflection anode having reduced capacitance, the use of a polyimide coating for the grid electrodes, the use of a compliant mounting and adjustment for a grid electrode assembly and the provision of an illuminated border on a magnetic matrix display.

[0002] A magnetic matrix display of the present invention is particularly although not exclusively useful in flat panel display applications such as television receivers and visual display units for computers, especially although not exclusively portable computers, personal organisers, communications equipment, and the like.

[0003] Conventional flat panel displays, such as liquid crystal display panels and field emission displays, are complicated to manufacture because they each involve a relatively high level of semiconductor fabrication, delicate materials, and high tolerances.

[0004] UK Patent Application 2304981 discloses a magnetic matrix display having a cathode for emitting electrons, a permanent magnet with a two dimensional array of channels extending between opposite poles of the magnet, the direction of magnetisation being from the surface facing the cathode to the opposing surface. The magnet generates, in each channel, a magnetic field for forming electrons from the cathode means into an electron beam. The display also has a screen for receiving an electron beam from each channel. The screen has a phosphor coating facing the side of the magnet remote from the cathode, the phosphor coating comprising a plurality of pixels each corresponding to a different channel.

[0005] In a colour magnetic matrix display, each of the corresponding phosphor pixels may be a group of phosphor elements, each group corresponding to a different channel and each group typically comprising a Red, a Green and a Blue phosphor element. There are first and second deflection anodes for sequentially addressing electron beams emerging from the channels to different ones of the phosphor elements thereby to produce a colour image on the screen. The first and second deflection anodes are arranged as a pair of combs.

[0006] There are grid electrodes disposed between the cathode and the magnet for controlling the flow of electrons from the cathode into each channel. These control grids comprise a first group of parallel control grid conductors (first grid) extending across the magnet surface in a column direction and a second group of parallel control grid conductors (second grid) extending across the magnet surface in a row direction so that each of the channels is situated at the intersection of a different combination of a row grid conductor and a column grid conductor. In operation, each of the first group of grid conductors are held at one of two fixed potentials, whilst each of the second group are driven to analog voltages that will determine the beam current which will flow.

[0007] Additionally, the grid drive voltages for certain applications such as a display using a very low beam current or using a high beam current may be outside the range desirable in order to minimise the cost of the grid drivers. The second grid conductors, which are driven by digital to analog converters (DACs), should ideally be capable of being driven at CMOS compatible voltages. Too high a voltage leads to expensive drivers, such as those which are used in Plasma panels. Too low a voltage leads to excessive difficulty in controlling beam current due to sensitivity to electrical noise, DAC linearity and the like.

[0008] Co-pending GB Patent Application 9611469.9 (Attorney Docket Reference UK9-96-031) discloses a sensor array plate consisting of metal strips across the path of the electron beam, separate from the normal grid structure. This provides real time active beam current sensing for each channel of a magnetic matrix display. Such a structure, having an array separate from the normal grid structure is complex and has many interconnections.

[0009] Co-pending GB Patent Application 9703807.9 (Attorney Docket Reference UK9-96-080) discloses a magnet for a magnetic matrix display having an insulated plate located on the side facing the cathode, the surface of the flat insulated plate facing the cathode being at a predetermined distance from the control grid (first grid) and being perforated with one or more apertures for each of the one or more electron beams. Such an insulated plate and the control grids mentioned above require several processes to make and leave small gaps which are difficult to evacuate when the glass envelope is evacuated. Additionally, the grid connections must be brought out to the driver chips, located external to the glass envelope.

[0010] One of the requirements of a magnetic matrix display is to precisely align the apertures in the magnet with the phosphor stripes on the screen. If uniform column stripes are used the problem becomes one of horizontal alignment and rotational alignment. Alignment of the structure to less than the width of one phosphor stripe is possible with the use of optical alignment aids, such as, for example, by aiming a laser through preselected apertures whilst the magnet and screen are held and adjusted in a fixture. However, some residual adjustment may be necessary after construction of the magnetic matrix display, to give optimal colour purity. Co-pending GB Patent Application 9612345.0 (Attorney Docket Reference UK9-96-030) discloses a method by which small horizontal adjustments may be made by introducing an offset voltage onto the deflection anodes. Co-pending GB Patent Application 9625235.8 (Attorney Docket Reference

UK9-96-064) discloses a method of electronic control of rotation, but such a method requires a more complex manufacturing process for the grid assembly.

[0011] Co-pending GB Patent Application 9706992.6 (Attorney Docket Reference UK9-96-081) discloses a magnet for a magnetic matrix display wherein the magnet extends beyond the area occupied by the array of channels such that the field strength in the channels at the periphery of the array is substantially equal to the field strength in channels at the centre of the array. This extended area is not used for the display of information due to the non-linearity of any display in this area. However, the area does produce a non-display border around the active display area, which increases the size of the display.

[0012] In accordance with the present invention, there is now provided a display device comprising: cathode means for emitting electrons; a permanent magnet; a two dimensional array of channels extending between opposite poles of the magnet; the magnet generating, in each channel, a magnetic field for forming electrons from the cathode means into an electron beam; a screen for receiving an electron beam from each channel, the screen having a phosphor coating comprising a plurality of groups of adjacent pixels facing the side of the magnet remote from the cathode, each corresponding to a different channel; grid electrode means disposed between the cathode means and the magnet for controlling flow of electrons from the cathode means into each channel, the grid electrode means comprising a plurality of parallel row conductors and a plurality of parallel column conductors arranged orthogonally to the row conductors, each channel being located at a different intersection of a row conductor and a column conductor, each intersection having a corresponding aperture in each of the row conductor and the column conductor, the apertures in the row conductors and the column conductors being different in size. The differing sizes of apertures allows the DACs driving the second grid or row conductors to be within a range of voltages which is compatible with the use of CMOS technology for the drivers and also to improve the control of the bean current and reduce sensitivity to electrical noise, DAC linearity and the like.

[0013] In a preferred embodiment, the apertures in the row conductors are smaller than the corresponding apertures in the column conductors. This increases the voltage sensitivity of the second grid (the row conductors) and allows the use of lower voltage drivers for a given beam current. Additionally, the edges of the first grid and second grid do not precisely coincide meaning that an insulating layer used between the first grid and the second grid may be extended.

[0014] Preferably, the grid electrode means further comprises a first insulating layer disposed between the row conductors and the column conductors, the first insulating layer having apertures intermediate in size between those of the row conductors and those of the column conductors. The positioning of such an insulating layer can be done with a low accuracy whilst still ensuring that the first and second grid tracks do not short together.

[0015] Viewed from a further aspect, the present provides a display device comprising: cathode means for emitting electrons; a permanent magnet; a two dimensional array of channels extending between opposite poles of the magnet; the magnet generating, in each channel, a magnetic field for forming electrons from the cathode means into an electron beam; a screen for receiving an electron beam from each channel, the screen having a phosphor coating comprising a plurality of groups of adjacent pixels facing the side of the magnet remote from the cathode, each corresponding to a different channel; grid electrode means disposed between the cathode means and the magnet for controlling flow of electrons from the cathode means into each channel and having a sensor electrode located thereon. The use of a combined sensor electrode and second grid structure reduces the complexity and the number of process steps as well as the number of interconnections from the sensor electrode to the second grid.

[0016] Viewed from yet another aspect, the present invention provides a display device comprising: cathode means for emitting electrons; a permanent magnet; a two dimensional array of channels extending between opposite poles of the magnet; the magnet generating, in each channel, a magnetic field for forming electrons from the cathode means into an electron beam; a screen for receiving an electron beam from each channel, the screen having a phosphor coating comprising a plurality of groups of adjacent pixels facing the side of the magnet remote from the cathode, each corresponding to a different channel; grid electrode means disposed between the cathode means and the magnet for controlling flow of electrons from the cathode means into each channel, the grid electrode means being formed on a polyimide substrate. The use of a polyimide substrate and double sided circuit construction techniques simplifies the construction of, and reduces the fragility of the grid assembly. Additionally, grid aperture dimensions of differing sizes may easily be used. Polyimide may be applied as a conformal polyimide coating thus removing any small gaps which would otherwise be difficult to evacuate.

[0017] In a preferred embodiment, the grid electrode means and the substrate extend beyond the two dimensional array of channels. Preferably, the display device further comprises an enclosing glass envelope and the grid electrode means and the substrate extend through the glass envelope. Further preferably, grid electrode driver chips are attached to the substrate.

[0018] More preferably, the display device further comprises a polyimide second insulating layer between the grid electrode means and the magnet. Yet more preferably, the display device further comprises a third polyimide insulating layer between the grid electrode means and the cathode. Preferably, a conducting film is present on the side of the third insulating layer facing the cathode. Further preferably, the conducting film is gold. The conducting film is a good reflector

of infrared radiation from the cathode filaments and can reflect most of the heat away from the polyimide and the magnet.

[0019] In a preferred embodiment, the magnet is a photomachineable magnet and the substrate forms an exposure mask for the photomachineable magnet. This simplifies the photomachining process for producing the apertures in the magnet.

[0020] Also, in a preferred embodiment, the display device further comprises a through-glass magnet position adjustment. This allows the precise alignment of the apertures in the magnet with the phosphor stripes on the screen. Preferably, the position adjustment causes rotation of the magnet with respect to the screen. If uniform column stripes of phosphor are used, then only horizontal and rotational alignment are needed. Horizontal alignment may be made simply by introducing an offset voltage onto the deflection anodes. Rotational alignment can be by means of the through-glass magnet position adjustment. More preferably, the adjustment is a screw and the screw is located within a crushable metal housing. A crushable metal housing is suitable since the adjustment is a once only manufacturing setting.

[0021] Viewed from a further aspect, the present invention provides a display device comprising: cathode means for emitting electrons; a permanent magnet; a two dimensional array of addressable channels extending between opposite poles of the magnet and a plurality of border channels extending in at least a first dimension beyond the area occupied by said two dimensional array of addressable channels; the magnet generating, in each channel, a magnetic field for forming electrons from the cathode means into an electron beam; a screen for receiving an electron beam from each addressable channel, the screen having a phosphor coating facing the side of the magnet remote from the cathode, the phosphor coating comprising a plurality of pixels each corresponding to a different addressable channel; grid electrode means disposed between the cathode means and the magnet for controlling flow of electrons from the cathode means into each addressable channel; wherein said screen has a phosphor coating corresponding to said border area channels. The magnet in the display is larger than the array of addressable channels used for the active display because of the need to improve the linearity of addressable channels near to the periphery of the magnet. The provision of an illuminated border reduces the apparent effect of the larger magnet on display size.

[0022] In a preferred embodiment, the phosphor coating forming the illuminated border is a single colour. This avoids the problems of adjusting the colour point of multiple phosphor colours and of purity errors due to the magnetic field non-linearity in this area.

[0023] In an alternative embodiment, the phosphor coating comprises a plurality of pixels having adjacent elements of differing colours; and the display device further comprises deflection means for sequentially addressing the electron beam from each channel to each element of the corresponding pixel. Preferably, the first grid for the border area is modulated. This allows precise adjustment of the colour point displayed to any colour within the region bounded by the phosphor colours. Alternatively, the adjacent elements in a pixel each receive the same beam current and the dimensions of each of the adjacent elements in a pixel are chosen so as to produce light of a pre-defined colour.

[0024] The present invention extends to a computer system comprising: memory means; data transfer means for transferring data to and from the memory means; processor means for processing data stored in the memory means; and a display device as claimed in any preceding claim for displaying data processed by the processor means.

[0025] Preferred embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a simplified cross-sectional view of an example of a prior art Magnetic Matrix Display device;

Figure 2 is a cutaway plan view of the example of figure 1;

Figure 3 is a view of prior art first and second control grids having equal diameter apertures;

Figure 4 is a view of first and second control grids according to the present invention having unequal diameter apertures giving increased voltage sensitivity;

Figure 5 is a view of first and second control grids according to the present invention having unequal diameter apertures giving decreased voltage sensitivity;

Figure 6 is a graph of beam current flowing versus second control grid voltage for varying size of second grid aperture;

Figure 7 shows a combined grid and beam current sensor assembly according to the present invention;

Figure 8 is a cross section of a prior art magnetic matrix display having an insulating plate;

Figure 9 is a cross section of a magnetic matrix display having an insulating polyimide coating according to the present invention;

Figure 10 is a cross section of the display of figure 9 showing polyimide and grids brought out through the glass envelope;

Figure 11 is a cross section of the display of figure 9 showing a compliant mounting for mechanical rotation adjustment;

Figure 12 is a front of screen view of a magnetic matrix display according to the present invention having an active display border; and

Figure 13 is a view of the active display area grid structure of a magnetic matrix display such as that of figure 12.

[0026] Referring to Figure 1, an example of a magnetic matrix display device 10 comprises a plane cathode 20 facing a plane anode 30. A phosphor coating 150 is disposed on the side of the anode 30 remote from the cathode. A permanent magnet 140 is disposed between the anode 30 and the cathode 20. The magnet 140 is perforated by a two dimensional matrix of channels 160. A grid assembly is disposed between the magnet 140 and the cathode 20. The grid assembly comprises first and second electrically isolated arrays of parallel conductors hereinafter referred to as first grids 71 and second grids 72 respectively. The first grids 71 are arranged orthogonally to the second grids 72 to form a lattice pattern. Apertures are formed in the first grids 71 and the second grids 72. The apertures are located at each intersection of a first grid 71 and a second grid 72. Each aperture is aligned with a different channel 160. The phosphor coating comprises a plurality of pixels each corresponding to a different channel. In a colour magnetic matrix display, each of the corresponding phosphor pixels may be a group of phosphor elements, each group corresponding to a different channel and each group typically comprising a Red, a Green and a Blue phosphor element. Deflection anodes 302,304 are arranged as a pair of combs between the magnet 140 and the anode 30 to sequentially address electron beams emerging from the channels to different ones of the phosphor elements.

[0027] Referring to Figure 2, column drive circuitry 170 is connected to the first grids 71. Row drive circuitry 180 is connected to the second grids 72. This has the advantage that for a conventional display having a four to three aspect ratio, with more columns than rows, the number of more complex expensive analog drivers is reduced at the cost of having more simple, cheap digital switches. Referring back to figure 1, in operation, the anode 30 is held at a higher potential than the cathode 20. Electrons emitted from the cathode 20 are thus accelerated towards the anode 30. As electrons enter each of the channels 160 in the magnet 140 they are collimated into a dense beam by the magnetic field therein. In operation, admittance of electrons to the channels is selectively controlled via the grid assembly. Each channel 160 is addressable by appropriate voltage signals applied by the row drive circuitry 180 and the column drive circuitry 170 to the corresponding first grid 71 and second grid 72. Electrons are thus selectively admitted or blocked from entering each channel 160, passing through the magnet 140 and reaching the corresponding region of the phosphor coating 150 to generate a pixel of a displayed image on the screen. The pixels of the displayed image are scanned in a refresh pattern. To produce the refresh pattern, a column of pixels is energised by applying an appropriate voltage, via the row drive circuitry 180 to the corresponding second grid 72 with the voltage on the first grids 71 set via the column drive circuitry 170 so that no beam current flows. The voltages on the remaining first grids 72 are set by the column drive circuitry 170 so that no beam current flows for any operating voltage on the second grids 71. The voltages on the second grids 72 are then modulated by row drive circuitry 180 as a function of input video data corresponding to the energised column of pixels. The process is then repeated for the next successive column. The row and column functions are transposed relative to that conventionally used in LCDs, that is the rows are driven by an analog voltage and the columns are switched between two analog levels, however such transposition is not an essential feature of a magnetic matrix display.

[0028] In some circumstances, the design of a magnetic matrix display may require the grid electrode drive voltages to be kept within a certain range of voltages in order to minimise the cost of the grid electrode drivers. A typical desired range is that of CMOS technology, in which the desired range of output voltages is between zero volts and approximately ten volts. "Conventional" grid apertures are sometimes not sufficient to achieve the desired beam current with these drive voltages. Two specific examples where these "conventional" grid apertures are not sufficient are:

1. A display which is to use a very low beam current, such as, for example, disclosed in co-pending GB Patent Application 9703741.0 (Attorney Docket Reference UK9-96-079). The beam current in such a display will be excessively sensitive to second grid electrode voltage, that is, the DAC driving the second grid electrode is only operating near to zero volts with correspondingly poor voltage quantisation and hence beam current quantisation.

2. A display which is to use a high beam current, such as, for example, a projection display or an avionic display readable in sunlight. In such a display, the second grid electrode voltage required is beyond that attainable from cost-effective CMOS drivers. The second grid electrode voltage required is determined by the transfer characteristics of the magnetic matrix display.

[0029] Figure 3 shows a conventional magnetic matrix display grid structure in which the apertures in the second grid 72 structure and the first grid 71 structures are equal in diameter.

[0030] Figure 4 shows a magnetic matrix display grid structure in which the apertures in the first grid are larger than the apertures in the second grid. This has the effect of "unmasking" the second grid and increasing the voltage sensitivity of the second grid, thus allowing lower second grid drive voltages to be used for a given beam current.

[0031] Figure 5 shows a magnetic matrix display grid structure in which the apertures in the second grid are larger than the apertures in the first grid. This has the effect of "masking" the second grid and decreasing the voltage sensitivity of the second grid, thus reducing the sensitivity of the second grid and improving the voltage quantisation and hence beam current quantisation.

[0032] A computer simulation of the variations in second grid aperture diameter has been completed. Table 1 below shows the first grid cutoff voltage values measured for a first grid aperture of 250μm and a second grid aperture of discrete values between 250μm and 100 μm.

Second grid Aperture (μm)	250	200	150	100
Cutoff Voltage (V)	-2.625	-2.65	-2.1	-1.875

Table 1 - Cutoff values with second grid voltage = 0 volts.

[0033] Table 2 below shows the beam currents obtained with the second grid set at voltages between 0 volts and 5 volts. One volt steps were used in the simulation, except for the case where the first grid aperture was 100μm, where 0.5 volt steps were used from 0 volts to 1 volt. Above this voltage the beam current increased rapidly.

Second grid (G2) Aperture (μm)	250	200	150	100
G2=0.0V	2.1nA	2.1nA	2.1nA	2.1nA
G2=0.5V	-------	-------	-------	395.4nA
G2=1.0V	182.5nA	241.7nA	347.2nA	736.5nA
G2=2.0V	322.5nA	439.0nA	604.1nA	-------
G2=3.0V	444.2nA	577.8nA	764.0nA	-------
G2=4.0V	521.4nA	698.8nA	901.9nA	-------
G2=5.0V	625.3nA	770.8nA	1021.4nA	-------

Table 2 - Second grid (G2) voltage (from cutoff) vs. beam current

[0034] Figure 6 shows the results of Table 2 in graphical form. It should be noted that the nature of the computer simulation is such that the true space charge behaviour in front of the physical cathode is not necessarily modelled. If this were modelled, then an increase in beam current for a given second grid (G2) voltage would be seen, that is the gamma

would increase. Thus with increasing beam current, the quantised current drawn from the emitter does not increase (as would be the real case), but instead remains constant, that is, the cathode is operating in a thermally saturation limited mode. Increases in beam current are due to increases in the cathode electron collection area. However, despite this being the case, the effect of changing relative grid hole diameters is clearly demonstrated.

[0035] Even though there is a "line of sight" path from the cathode to exposed second grid (G2) tracks, electrons are still subject to the strong focusing and collimation effects inherent in the design of the magnetic matrix display. Even at highly positive second grid voltages, no electrons passing through the channels in the magnet collide with the second grid, demonstrating the high display efficiency that can be maintained with this invention.

[0036] A further advantage of using a second grid aperture smaller than a first grid aperture is that the edges of the first grid and second grid apertures do not precisely coincide. This means that the insulating layer used between the first grid and the second grid can be extended. For example, if a 150μm diameter second grid aperture is used with a 250μm diameter first grid aperture, the aperture in the insulating layer could be, for example, 200μm diameter, thus permitting low accuracy of placement of the insulating layer whilst still ensuring that the first grid and second grid tracks do not short together.

[0037] Co-pending GB Patent Application 9611469.9 (Attorney Docket Reference UK9-96-031) discloses a sensor array plate consisting of metal strips across the path of the electron beam, separate from the normal grid structure. This provides real time active beam current sensing for each channel of a magnetic matrix display. Such a structure, having an array separate from the normal grid structure is complex and has many interconnections.

[0038] Figure 7 shows a combined second grid and sensor assembly. The use of a sensor assembly reduces the effects of manufacturing tolerances on the magnetic matrix display as well as eliminating problems of non-uniformity in the cathode and low frequency instability present in some cathode types. The sensor array plate consists of a series of metal strips 1400 located along each of the second grid 72 conductors, such that the metal strips 1400 cross each of the apertures in the second grid 72 conductors in order to sense the beam current flowing. The sensor strips 1400 are electrically isolated from the first grids 71. The current flowing in each of the sensor strips corresponds to the beam current flowing only in pixels of the corresponding column of pixels.

[0039] By combining the sensor array plate structure with the second grid structure, the number of process steps and subassemblies can be reduced. The structure of figure 7 can be manufactured by well known production techniques for creating small thin film grids over holes such as that described by M Yamaguchi in "Fluorescent indicator panel with simple diode construction", SID Digest 1987.

[0040] The advantages of the structure shown in figure 7 are:

1. One process step instead of three;
2. A subassembly is eliminated;
3. The sensor voltage is kept at the optimum value for minimum electrostatic field disturbance because the sensor is at the same potential as the second grid electrode; and
4. Several hundred interconnections from the sensor to the drive circuits are eliminated, because there is no separate connection to the sensor.

[0041] The electronic drive circuits associated with the sensor array plate are unchanged from that described in co-pending GB Patent Application 9611469.9 (Attorney Docket Reference UK9-96-031).

[0042] Figure 8 shows a section through a magnetic matrix display. Such a display requires the preparation of a magnet 140 in the shape of a plate typically 1 or 2 mm thick, perforated with a matrix of holes, with each hole being typically 0.2 mm in diameter, and the holes being typically located on 0.3 mm centres. Deflection anodes 302,304 are then deposited on the top surface of the magnet 140, and orthogonal first 71 and second 72 control grids are deposited on the lower surface. The first 71 and second 72 control grids are separated by an insulating layer 1505. Under these control grids is placed an insulating layer 1510, which is preferably made from ceramic. A conducting film 1515 is deposited on the lower surface of the insulating layer 1510. Each of the layers described has apertures which align with the channels in the magnet 140 to form an aperture extending through the whole structure.

[0043] The structure shown in figure 8 has the problem that the first 71 and second 72 grid layers and the insulating layer 1505 are deposited directly on the magnet and then the insulating layer 1510 is placed beneath these layers. This requires several different processes and also leaves small gaps which makes the assembly difficult to evacuate. There is also no provision for the first 71 and second 72 grid connections to be brought out to the driver chips, which are typically external to the evacuated final glass envelope.

[0044] Flexible printed circuits based on single, double or multi-layer techniques are well known in the electronic industry, and are extensively used in liquid crystal displays, electro-luminescent displays and other displays. They almost exclusively use a substrate called polyimide, which is stable in a vacuum environment. When coated with copper circuit tracks, polyimide offers good integrity and stability and is available in very large sizes. Conformal polyimide coatings can be applied to cover exposed copper or other conductive tracks and give a smooth flat surface.

[0045] Figure 9 shows a section through a magnetic matrix display including a polyimide coating of the present invention. Such a display requires the preparation of a magnet 140 in the shape of a plate typically 1 or 2 mm thick, perforated with a matrix of holes, with each hole being typically 0.2 mm in diameter, and the holes being typically located on 0.3 mm centres.

[0046] Deflection anodes 302,304 are deposited on the top surface of the magnet 140. These could be deposited on a polyimide substrate and laminated to the magnet or they can be deposited conventionally. The deflection anodes are preferably about 1μm in thickness. A thick base or conformal coating can be used if it is desired to space the anodes off the magnet surface, to provide a spacing of up to 0.2 mm. This spacing could be increased if a different material were used.

[0047] Orthogonal first 71 and second 72 control grids are initially deposited as a double sided circuit with a polyimide substrate 1610. Each of the first 71 and second 72 grids are preferably about 1μm in thickness. The polyimide substrate 1610 is preferably about 10 μm in thickness. Then a thin conformal coat 1605 of about 1μm thickness is applied to the top, so as to eliminate voids and allow the circuit to be placed directly on the magnet surface. Then, a much thicker base 1615, preferably about 100μm thick gives the thickness required to form the insulating plate. Polyimide is an excellent insulator and may be made to a very high dimensional accuracy. Finally, a grounded, conducting metallic coating 1515 is applied. This is preferably a gold film of about 100nm thickness, in order to reflect infra-red radiation from the cathode.

[0048] Each of the layers described above has apertures which align with the channels in the magnet 140 to form an aperture extending through the whole structure. These apertures can be made through the structure by punching or by etching. If a photomachineable magnet such as is described in co-pending GB Patent Application 9614682.4 (Attorney Docket Reference UK9-96-036) is used, then the perforated polyimide circuit could be used as an exposure mask.

[0049] The use of a double sided circuit with polyimide substrates allows complete freedom to modify grid aperture dimensions, for example, by making them smaller than the magnet aperture diameter, or by making one of the grids such as the second grid smaller or larger than the other.

[0050] Existing attachment technologies can be adapted for attaching the finished polyimide circuit to the magnet 140, using pinning or a vacuum stable epoxy resin. There will be no electron bombardment of the adhesive, since the electron paths are separated from it.

[0051] When the polyimide circuit is attached to the magnet 140, the resultant lamination considerably reduces the fragility of the large perforated ceramic magnet structure.

[0052] The flexible circuit (1605,71,1610,72,1615,1515) can be extended beyond the area of the magnet 140, so bringing out the grids to an area where the integrated circuit drive chips can be attached. This can be inside the enclosing evacuated glass envelope or in a preferred embodiment shown in figure 10, can be outside the evacuated glass envelope.

[0053] Figure 10 shows the substrate and grid assembly 1600 of figure 9, together with top side supports 1710 and bottom side supports 1720, which are part of the glass envelope. The polyimide substrate and grid assembly (flexible circuit) is brought out 1740 through the glass to provide circuit connection and drive chip mounting. The conducting gold film provides a grounded reference plane for the cathode and so connection may be made external to the glass envelope. A bond and vacuum seal 1730 is used between each of the top side supports 1710 and the substrate and grid assembly 1600 and between each of the bottom side supports 1720 and the substrate and grid assembly 1600.

[0054] The polyimide substrate cannot stand the high temperature of frit sealing, so the vacuum bond has to be an epoxy resin which is readily available and designed for this kind of vacuum sealing application.

[0055] When the circuit is attached to the magnet, there may be differential expansion between the magnet material and the polyimide when heated by, for example, residual heat from the cathode filaments. The expansion of a glass bound magnet is of the order of 10^{-5}/°C or 0.1% for a 100°C temperature rise. The expansion of polyimide is of the order of 5×10^{-5}/°C or 0.5% for a 100°C temperature rise, that is five times greater than that of the magnet material. Over a diagonal of 16" (406 mm), this gives a differential linear dimension change of 0.4% for a 100°C temperature rise. If the polyimide is firmly attached to the magnet, this may cause a problem with mechanical stress. Techniques to reduce the differential change include using a glass filled polyimide film to reduce the differential linear dimension change to 0.04% for a 100°C temperature rise or using magnet material with modified properties. Such a technique is well known in the art and causes the glass filling to more closely match the expansion of the glass bound magnet.

[0056] Where the polyimide circuit structure is taken out through the glass, there can be differential expansion giving stress on the circuit structure. There are many prior art techniques for solving this problem. An example of such a technique is to remove the polyimide in a thin strip leaving the copper tracks with a small loop as a bridge to give stress relief.

[0057] A typical cathode used in a magnetic matrix display is a thermionic remote virtual area type, which comprises of a large number of filament wires each operating at 750°C, with a total input power of 50W. The polyimide and the magnet cannot be allowed to exceed 200°C to 250°C and so measures to remove or reduce the heat load must be taken. The metal film (1515 in figures 9, 10) that must be deposited on the lower surface of the polyimide can be used to assist this process. If the metal film is made a good reflector of infra-red radiation (the only major source of heat trans-

fer in a vacuum) and if the back of the display is made matt black with a good conduction path to the outside of the display, then most of the heat can be reflected away from the polyimide and magnet, absorbed by the black coat and conducted away. A 100nm layer of gold gives over 90% infra-red radiation reflection, although thinner coats or other materials can be used. Such a coating costs about $1.75 for a 17" (432 mm) display.

[0058] The polyimide mounting for the magnet assembly described above has strain relief at the point where the flexible circuit is taken out through the glass and this forms a compliant mounting for small movements. Figure 11 discloses a preferred embodiment of the present invention, in which a screw adjustment 1805 is brought out through the glass by means of a metal bush 1810. The screw adjustment, in conjunction with an appropriate compliant fixing internally, allows a mechanical rotational adjustment. For a rotational adjustment, only one adjustment screw is needed, although more can be added if this is preferred. The adjustment range required is in the order of ±50μm. Since this adjustment is a once only adjustment during manufacturing, a crushable, soft metal housing 1810 can be used for the screw 1805. An epoxy seal is provided between the soft metal bushing 1810 and the glass side support 1710.

[0059] Co-pending GB Patent Application 9706992.6 (Attorney Docket reference UK9-96-081) discloses a magnet for a magnetic matrix display wherein the magnet extends beyond the area occupied by the array of addressable channels such that the field strength in the addressable channels at the periphery of the array is substantially equal to the field strength in channels at the centre of the array. To avoid unwanted electrons being attracted through apertures outside the array of addressable channels by the final anode potential and disrupting display operation, the apertures are blocked, either physically by a non-magnetic material or electrostatically by additional first grid conductors held at the non-select level.

[0060] An alternative to excluding electrons from these apertures is to permit their passage, but in a controlled manner, and to use these additional electron beams to enhance the operation and features of the display.

[0061] The control of beam current through these apertures is achieved in the same manner as is described in co-pending GB Patent Application 9703741.0 (Attorney Docket Reference UK9-96-079), that is the use of a grid electrode covering a plurality of apertures, thus having the effect of a large pixel corresponding to multiple channels in the magnet.

[0062] Figure 12 shows a first preferred embodiment, in which the phosphor screen has a white phosphor border. In this embodiment, the Red 1905, Green 1910 and Blue 1915 phosphor stripes are fully enclosed within a border region 1920 of White phosphor, separated by black matrix material 1925. The width of the black matrix 1925 at the phosphor interface may be increased to avoid potential colour purity errors, introduced by the electron beams from the active display area. A White phosphor has been described in this embodiment, but the phosphor could be any single colour phosphor and limitation to a White phosphor is not intended.

[0063] In a second embodiment, the existing Red, Green and Blue phosphors deposited on the screen faceplate are used, but these are driven by the continuous electron beams from the display periphery. Since the relative efficiency of the phosphors is different, the colour point of this portion of the image must be set. This can be accomplished in one of two ways:

1. The relative areas of the different phosphors may be modified in this region such that, for a constant beam current, the resultant white colour point is achieved; or

2. The first grid 71 voltage used to drive these peripheral apertures is modulated in accordance with the deflection anode 302,304 differential voltage such that different beam currents may be delivered to each of the Red, Green and Blue phosphors.

[0064] The second technique has the advantage that it permits adjustment of the white colour point by voltage rather than physical adjustment. Indeed, the colour point may be adjusted to a colour other than white, limited only by the region defined by the phosphors.

[0065] Due to the inherent magnetic field non-linearity at the display periphery, a White (or other single colour) phosphor border is preferable. Use of the overscanned Red, Green and Blue phosphor border can cause problems with the placing of phosphor stripes such that the electron beams trikes them without obvious purity errors.

[0066] Figure 13 shows a modification to the active display grid structure which is needed if an illuminated border is used. The active display area is indicated by the area within the dashed outline and including the reference numeral 2005. The first grid 71 and second grid 72 tracks are narrowed to pass between the border pixel apertures 2010 and the grid 2015 used to control the border illumination is separately fabricated.

Claims

1. A display device comprising: cathode means (20) for emitting electrons; a permanent magnet (140); a two dimensional array of channels (160) extending between opposite poles of the magnet; the magnet generating, in each

channel, a magnetic field for forming electrons from the cathode means into an electron beam; a screen for receiving an electron beam from each channel, the screen having a phosphor coating (150) comprising a plurality of groups of adjacent pixels facing the side of the magnet remote from the cathode, each corresponding to a different channel; grid electrode means (71, 72) disposed between the cathode means and the magnet for controlling flow of electrons from the cathode means into each channel, the grid electrode means comprising a plurality of parallel row conductors (72) and a plurality of parallel column conductors (71) arranged orthogonally to the row conductors, each channel being located at a different intersection of a row conductor and a column conductor, each intersection having a corresponding aperture in each of said row conductor and said column conductor, the apertures in said row conductors and said column conductors being different in size.

2. A display device as claimed in claim 1 wherein said apertures in said row conductors (72) are smaller than said corresponding apertures in said column conductors (71).

3. A display device as claimed in claim 2 wherein said grid electrode means (71, 72) further comprises an insulating layer disposed between said row conductors (72) and said column conductors (71), said insulating layer having apertures intermediate in size between those of said row conductors and those of said column conductors.

4. A display device comprising: cathode means (20) for emitting electrons; a permanent magnet (140); a two dimensional array of channels (160) extending between opposite poles of the magnet; the magnet generating, in each channel, a magnetic field for forming electrons from the cathode means into an electron beam; a screen for receiving an electron beam from each channel, the screen having a phosphor coating (150) comprising a plurality of groups of adjacent pixels facing the side of the magnet remote from the cathode, each corresponding to a different channel; grid electrode means (71, 72) disposed between the cathode means and the magnet for controlling flow of electrons from the cathode means into each channel and having a sensor electrode (1400) located thereon.

5. A display device comprising: cathode means (20) for emitting electrons; a permanent magnet (140); a two dimensional array of channels (160) extending between opposite poles of the magnet; the magnet generating, in each channel, a magnetic field for forming electrons from the cathode means into an electron beam; a screen for receiving an electron beam from each channel, the screen having a phosphor coating (150) comprising a plurality of groups of adjacent pixels facing the side of the magnet remote from the cathode, each corresponding to a different channel; grid electrode means (71, 72) disposed between the cathode means and the magnet for controlling flow of electrons from the cathode means into each channel, said grid electrode means being formed on a polyimide substrate (1610).

6. A display device as claimed in claim 5 further comprising:

   an enclosing glass envelope (1710, 1720);

   a through glass magnet position adjustment (1805, 1810); and
   wherein said grid electrode means and said substrate (1610) extends through said glass envelope.

7. A display device as claimed in claim 5 further comprising a polyimide first insulating layer (1605) between said grid electrode means and said magnet.

8. A display device as claimed in claim 4 further comprising a polyimide second insulating layer (1615) between said grid electrode means (71, 72) and said cathode (20).

9. A display device as claimed in claim 8 further comprising a conducting film (1515) on the side of said second insulating layer (1615) facing the cathode (20).

10. A display device as claimed in claim 5 wherein said magnet (140) is a photomachinable magnet and said substrate forms an exposure mask for said photomachinable magnet.

11. A display device comprising: cathode means (20) for emitting electrons; a permanent magnet (140); a two dimensional array of addressable channels (160) extending between opposite poles of the magnet and a plurality of border channels extending in at least a first dimension beyond the area occupied by said two dimensional array of addressable channels; the magnet generating, in each channel, a magnetic field for forming electrons from the cathode means into an electron beam; a screen for receiving an electron beam from each addressable channel,

the screen having a phosphor coating (150) facing the side of the magnet remote from the cathode, the phosphor coating comprising a plurality of pixels each corresponding to a different addressable channel; grid electrode means (71, 72) disposed between the cathode means and the magnet for controlling flow of electrons from the cathode means into each addressable channel; wherein said screen has a phosphor coating corresponding to said border area channels.

12. A display device as claimed in claim 11 wherein said phosphor coating corresponding to said border area channels is a single colour.

13. A display device as claimed in claim 11 wherein said phosphor coating comprises a plurality of pixels having adjacent elements; and said display device further comprises deflection means (302, 304) for sequentially addressing the electron beam from each channel to each element of the corresponding pixel.

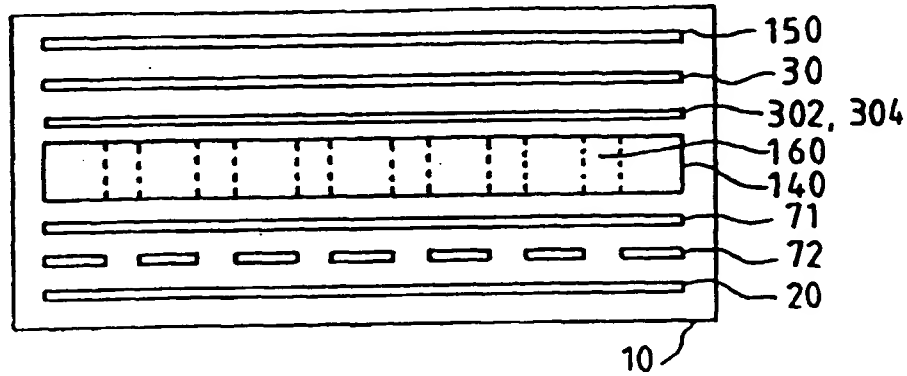

FIG. 1

PRIOR ART

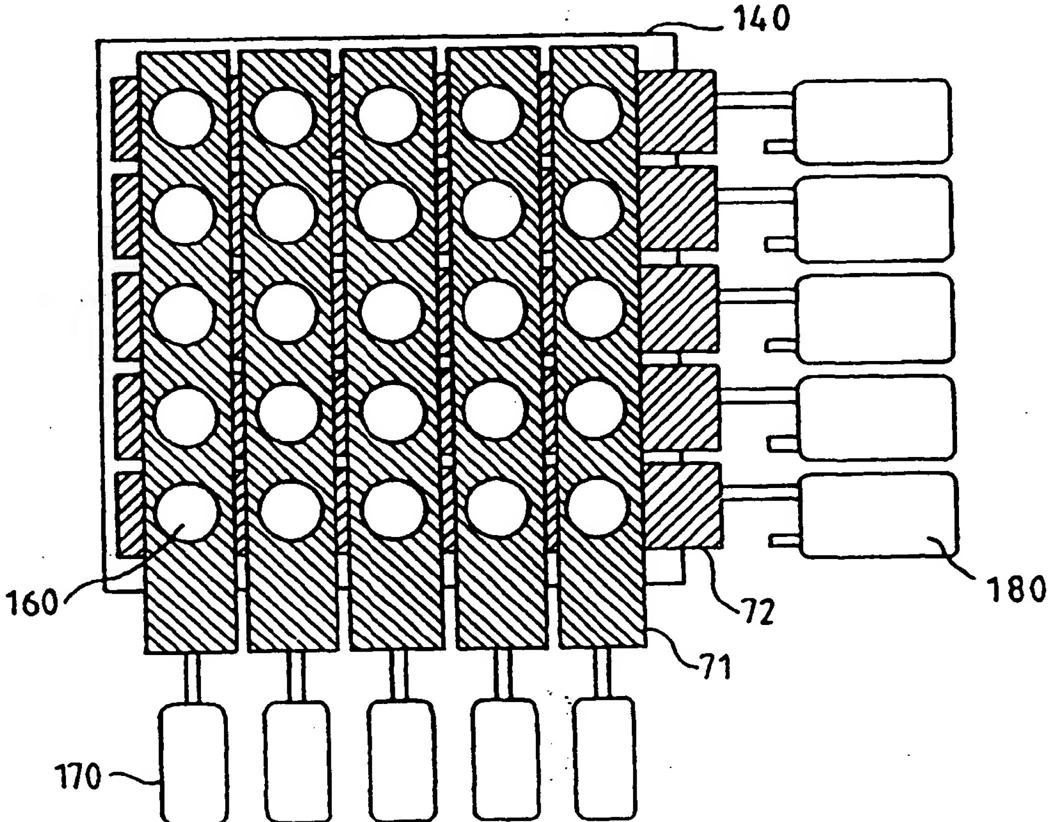

FIG. 2

PRIOR ART

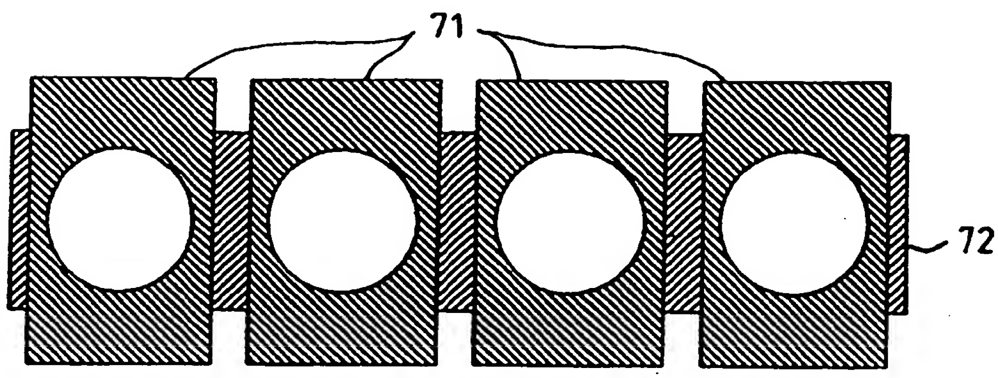

FIG. 3

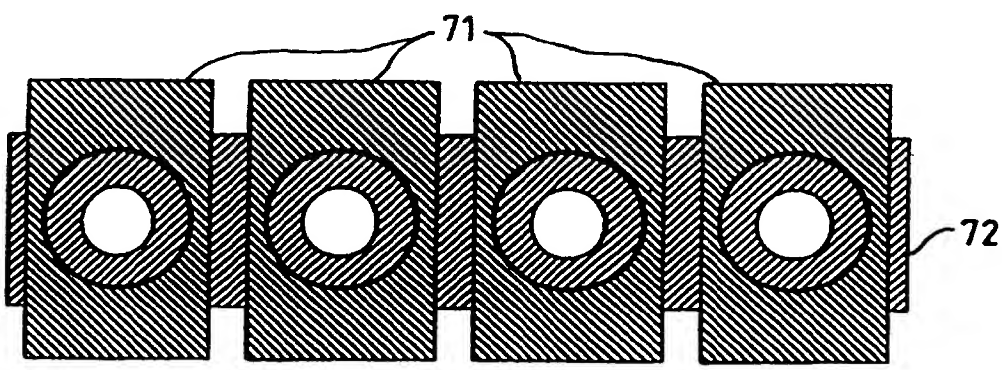

FIG. 4

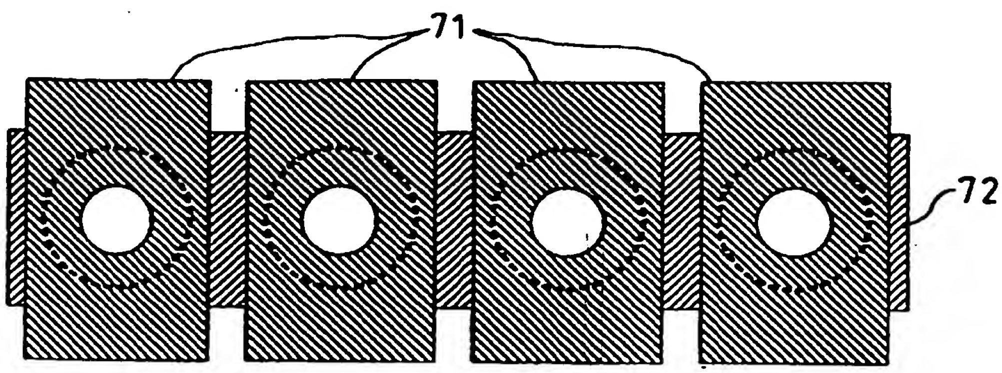

FIG. 5

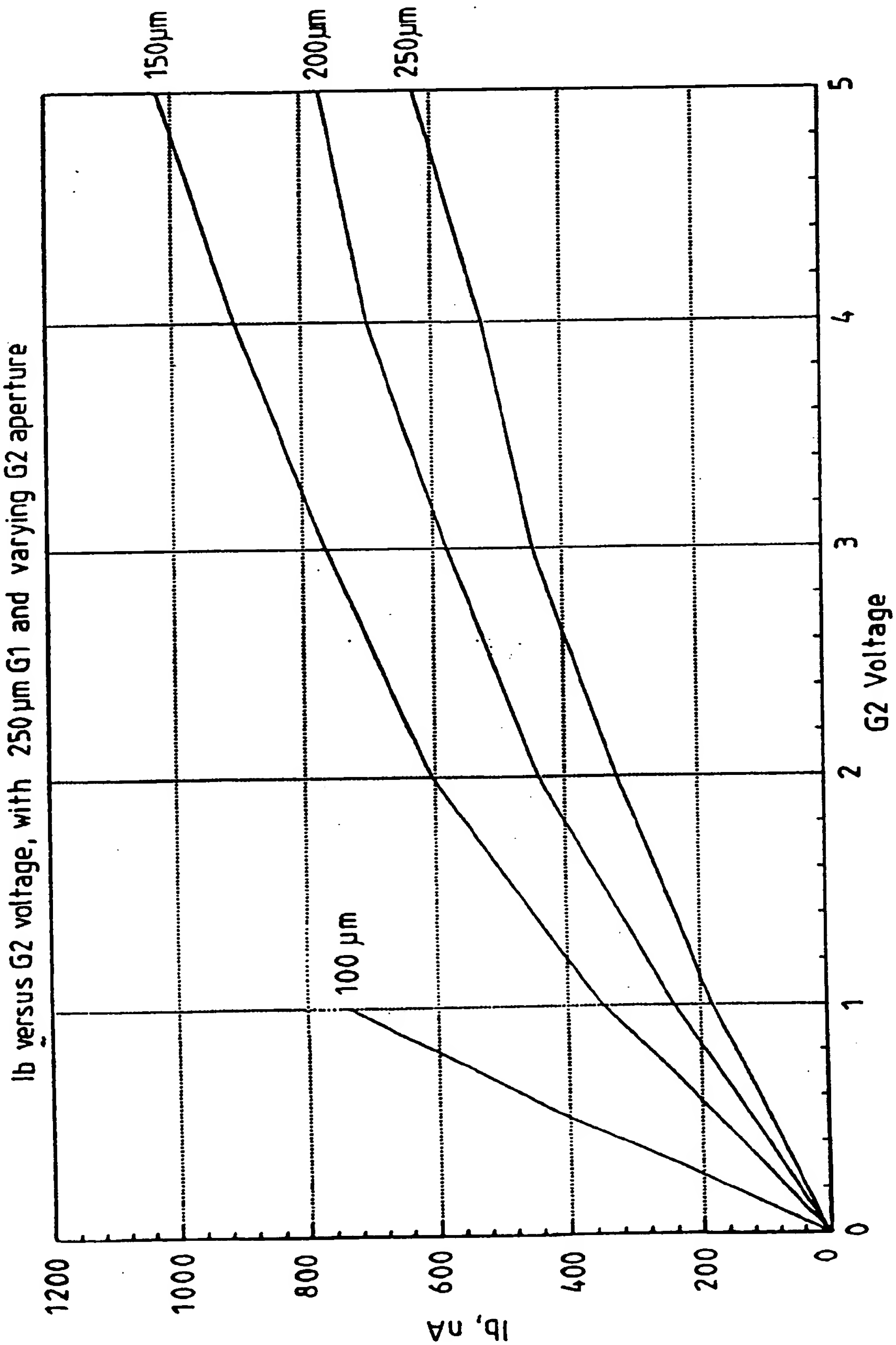
Ib versus G2 voltage, with 250 µm G1 and varying G2 aperture
150µm
200µm
250µm
100 µm
Ib, nA
1200
1000
800
600
400
200
0
0
1
2
3
4
5
G2 Voltage

FIG. 6

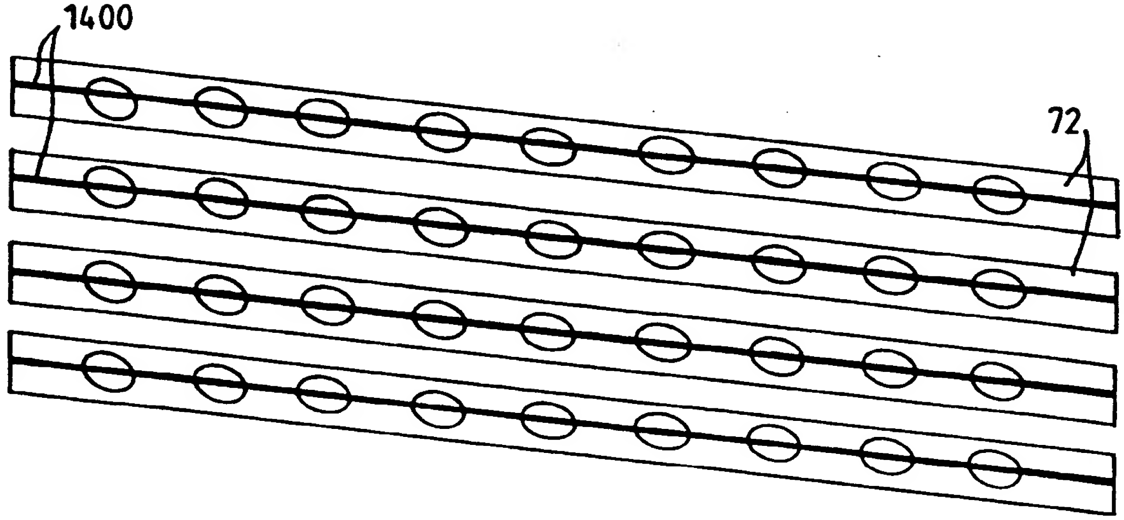

FIG. 7

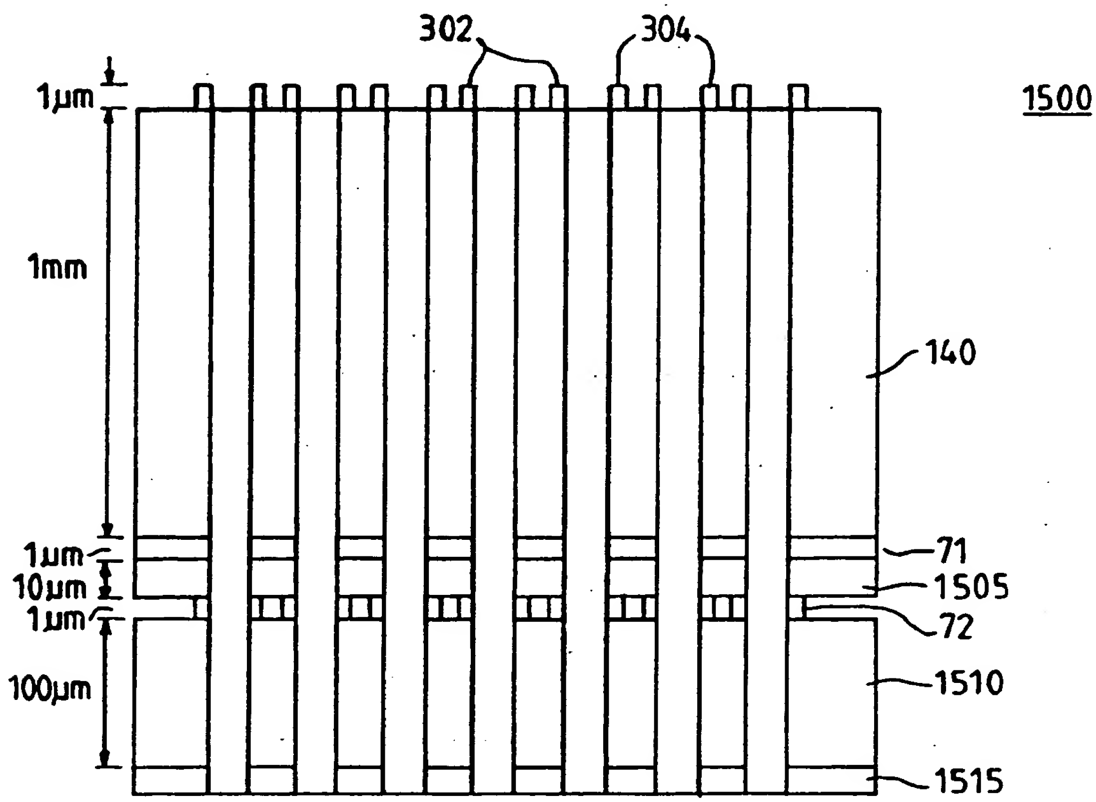

FIG. 8
PRIOR ART

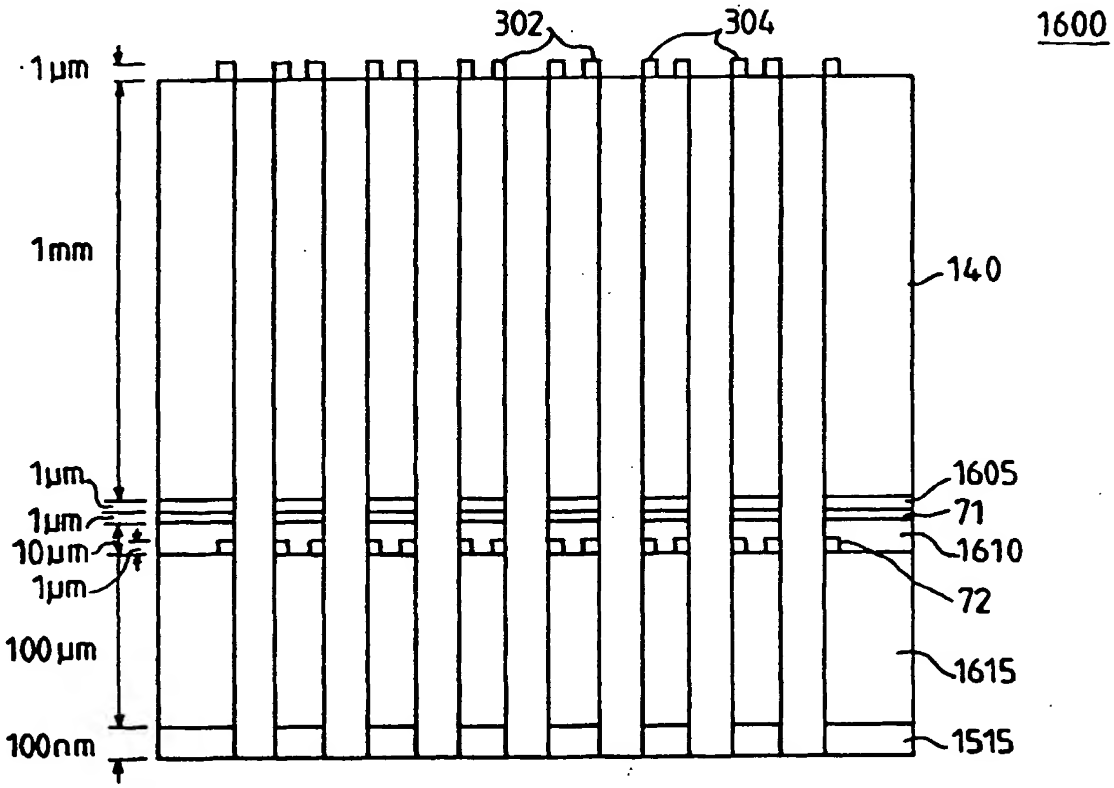
1600
302
304
1 µm
1mm
140
1µm
1µm
10µm
1µm
100µm
100nm
1605
71
1610
72
1615
1515

FIG. 9

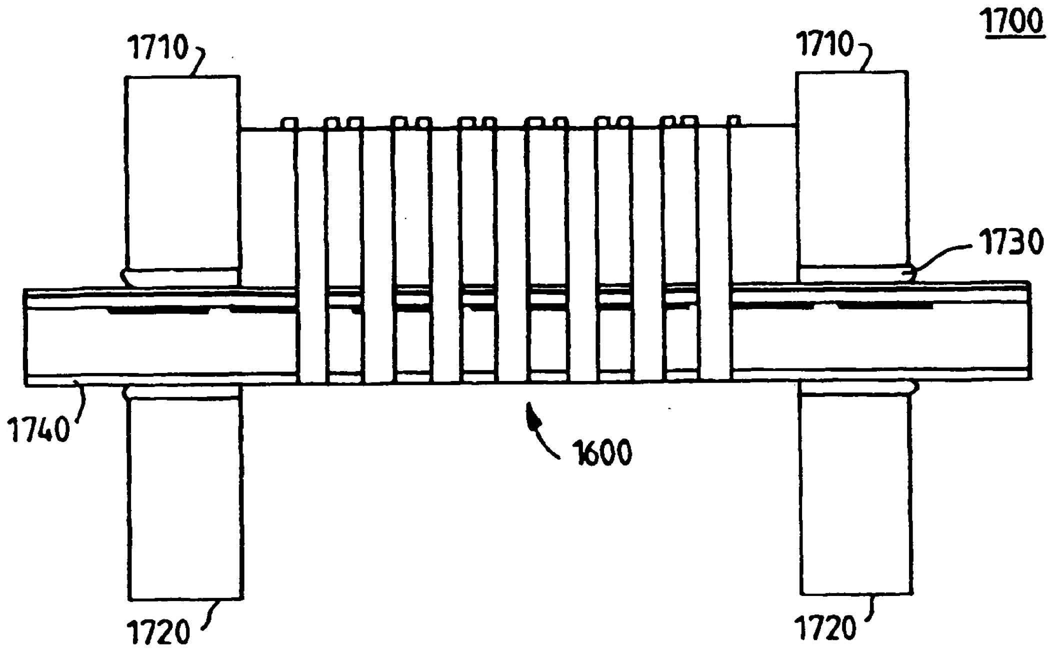
1700
1710
1710
1730
1740
1600
1720
1720

FIG. 10

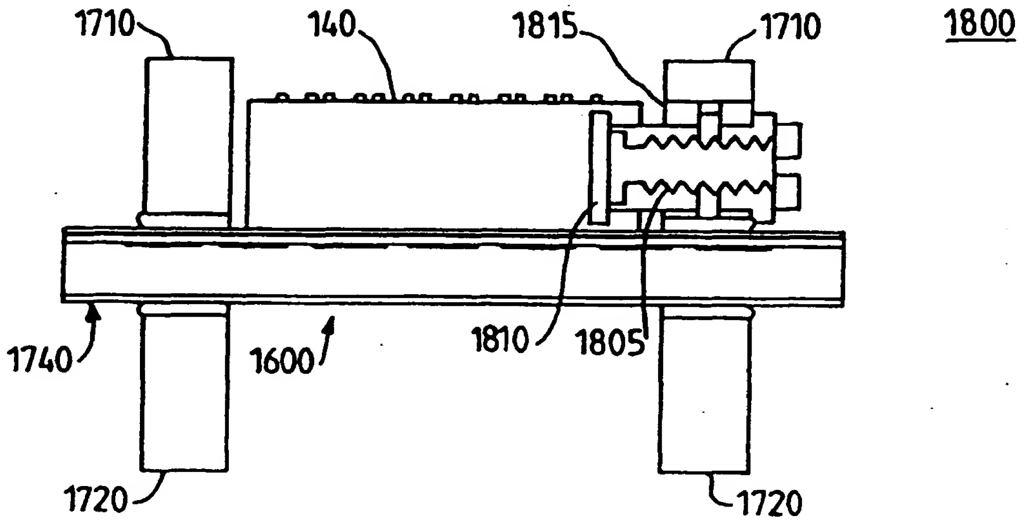
1710
140
1815
1710
1800
1740
1600
1810
1805
1720
1720

FIG. 11

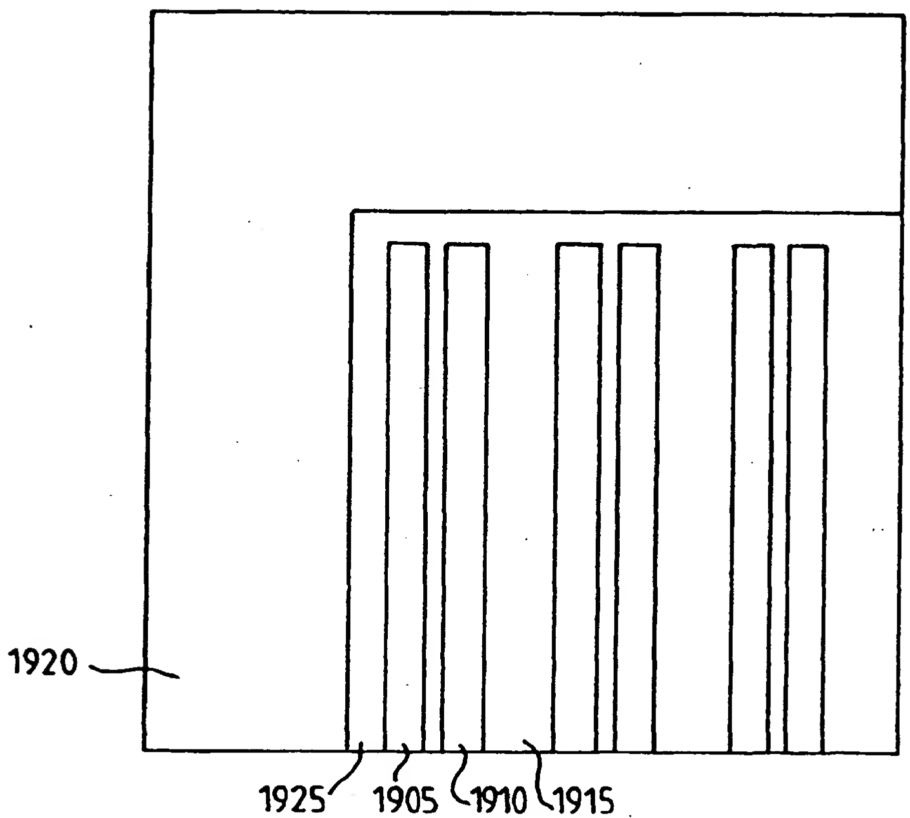
1920
1925
1905
1910
1915

FIG. 12

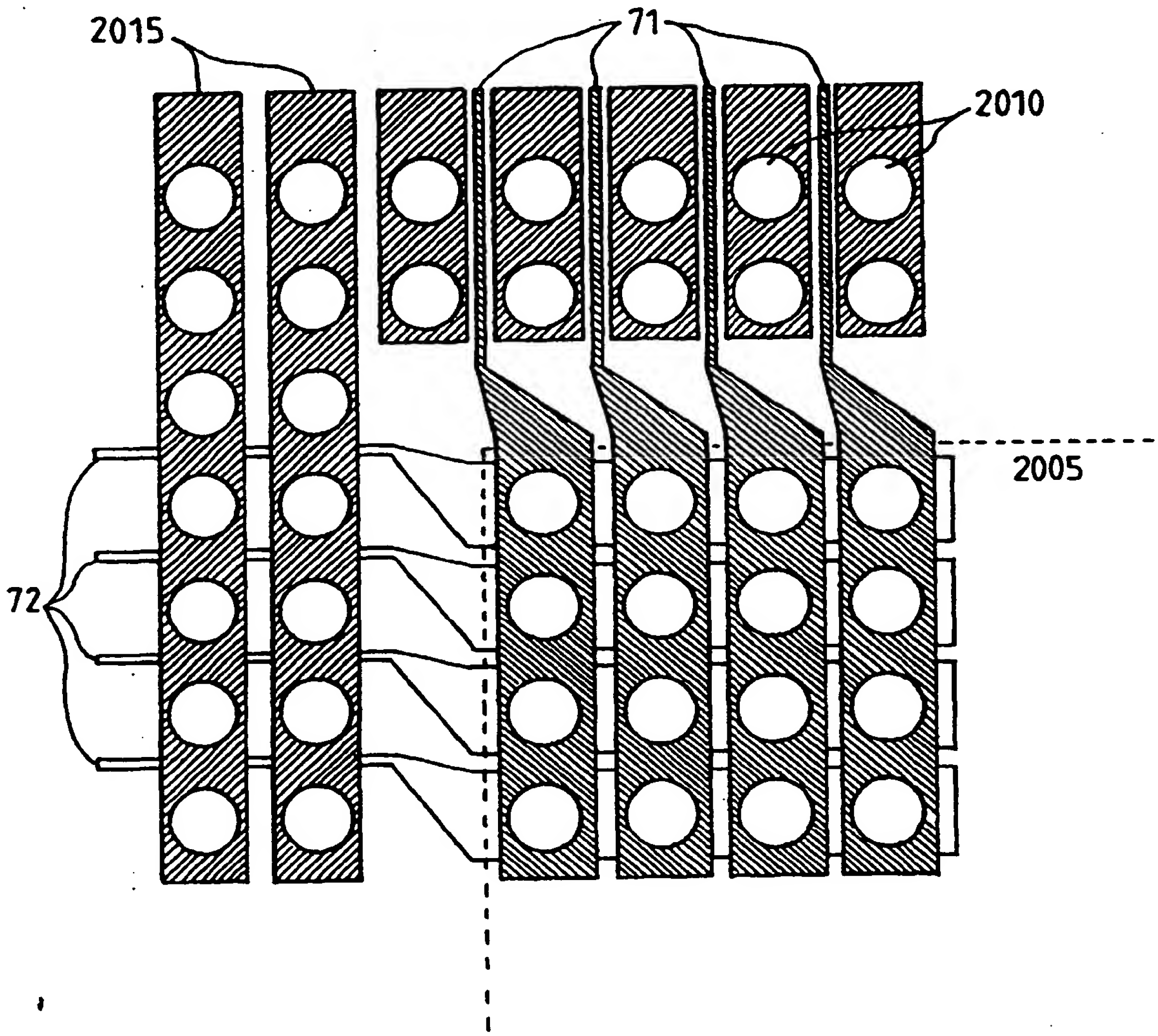

FIG. 13

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 30 4629

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP 0 213 675 A (PHILIPS ELECTRONIC ASSOCIATED ;PHILIPS NV (NL)) 11 March 1987 * claim 1 *	5	H01J31/12
A	EP 0 254 357 A (PHILIPS ELECTRONIC ASSOCIATED ;PHILIPS NV (NL)) 27 January 1988 * claim 1 *	5	
A	WO 94 18694 A (SILICON VIDEO CORP) 18 August 1994 * page 3, line 8 - line 17 *	5	
A	WO 97 08726 A (BEETESON JOHN ;KNOX ANDREW (GB); IBM (US)) 6 March 1997 * claims 1,24 *	1	
A	WO 97 08730 A (IBM ;BEETESON JOHN (GB); KNOX ANDREW (GB); KERIGAN SHAUN (GB)) 6 March 1997 * claim 1 *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
D,A	GB 2 304 984 A (IBM) 26 March 1997 * claims 1,30 *	1	H01J
A	EP 0 834 900 A (IBM) 8 April 1998	1-14	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	13 November 1998	Van den Bulcke, E

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03 82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 30 4629

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

13-11-1998

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0213675 A	11-03-1987	GB 2179784 A	11-03-1987
		JP 1961263 C	10-08-1995
		JP 6097598 B	30-11-1994
		JP 62052834 A	07-03-1987
		KR 9402142 B	18-03-1994
		US 4742267 A	03-05-1988
EP 0254357 A	27-01-1988	GB 2193372 A	03-02-1988
		JP 63034843 A	15-02-1988
		KR 9505580 B	25-05-1995
		US 4743798 A	10-05-1988
WO 9418694 A	18-08-1994	US 5589731 A	31-12-1996
		US 5477105 A	19-12-1995
		AU 6163494 A	29-08-1994
		EP 0683920 A	29-11-1995
		JP 8508846 T	17-09-1996
		US 5532548 A	02-07-1996
		US 5742117 A	21-04-1998
		US 5675212 A	07-10-1997
		US 5667418 A	16-09-1997
		US 5576596 A	19-11-1996
		US 5725787 A	10-03-1998
		US 5614781 A	25-03-1997
		US 5746635 A	05-05-1998
WO 9708726 A	06-03-1997	GB 2304981 A	26-03-1997
		EP 0846331 A	10-06-1998
		GB 2304983 A	26-03-1997
		WO 9708730 A	06-03-1997
		GB 2304984 A	26-03-1997
		GB 2304985 A	26-03-1997
		GB 2304986 A	26-03-1997
		GB 2304987 A	26-03-1997
		GB 2304988 A	26-03-1997
		GB 2318209 A	15-04-1998
		JP 9063517 A	07-03-1997
		US 5760548 A	02-06-1998
		US 5747923 A	05-05-1998
		US 5753998 A	19-05-1998

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 30 4629

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

13-11-1998

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9708730 A	06-03-1997	GB 2304981 A	26-03-1997
		EP 0846331 A	10-06-1998
		WO 9708726 A	06-03-1997
		GB 2304983 A	26-03-1997
		GB 2304984 A	26-03-1997
		GB 2304985 A	26-03-1997
		GB 2304986 A	26-03-1997
		GB 2304987 A	26-03-1997
		GB 2304988 A	26-03-1997
		GB 2318209 A	15-04-1998
		JP 9063517 A	07-03-1997
		US 5760548 A	02-06-1998
		US 5747923 A	05-05-1998
		US 5753998 A	19-05-1998
GB 2304984 A	26-03-1997	GB 2304981 A	26-03-1997
		EP 0846331 A	10-06-1998
		WO 9708726 A	06-03-1997
		GB 2304983 A	26-03-1997
		WO 9708730 A	06-03-1997
		GB 2304985 A	26-03-1997
		GB 2304986 A	26-03-1997
		GB 2304987 A	26-03-1997
		GB 2304988 A	26-03-1997
		GB 2318209 A	15-04-1998
		JP 9063517 A	07-03-1997
		US 5760548 A	02-06-1998
		US 5747923 A	05-05-1998
		US 5753998 A	19-05-1998
EP 0834900 A	08-04-1998	GB 2317987 A	08-04-1998
		JP 10112273 A	28-04-1998

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82